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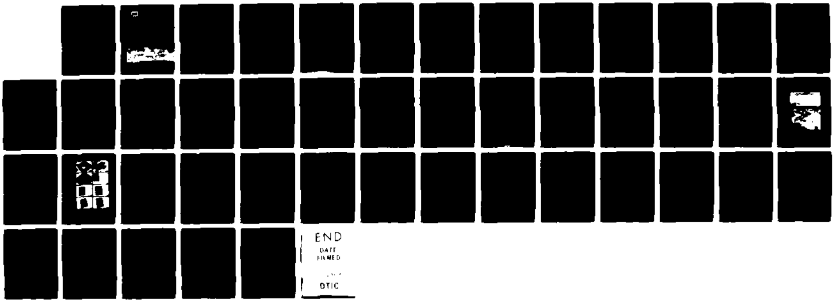

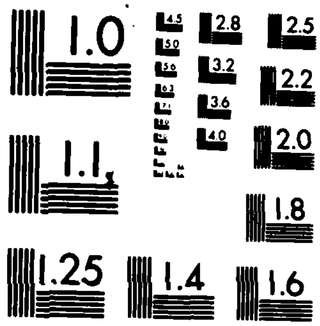

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SITE CHARACTERIZATION FOR SMOKE WEEK III BATTLEFIELD OBSCURATION TESTS AT EGLIN AIR FORCE BASE, FLORIDA

by

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The dusty atmosphere of the battlefield can seriously impede the performance of many electro-optical systems. The Smoke Week III tests were conducted at Eglin Air Force Base, Florida, in August 1980, by the Program Manager's Office for Smoke/Obscurants to measure the effects of battlefield environments on such systems. A part of those tests consisted of generating dust by detonating high explosives at the terrain surface. The work

(Continued)

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described in this report was performed to determine the atmospheric loading effects of those explosives and the relevant properties of the terrain. The report provides the measurements made and the results obtained and describes the terrain tested.

PREFACE

The work described herein was conducted in support of the Office of the Program Manager for Smoke/Obscurants (USA-DARCOM) under Intra-Army Order Number 80S2, dated 9 July 80.

Field measurements were conducted by Mr. James B. Mason under the general supervision of Dr. Lewis E. Link of the Environmental Systems Division, Environmental Laboratory. Soil samples were analyzed in the Soil Mechanics Division of the Geotechnical Laboratory and the Concrete Technology Division of the Structures Laboratory.

The Chief of the Environmental Systems Division at the time of these tests and during the preparation of this report was Mr. Bob O. Benn. The Chief of Environmental Laboratory was Dr. John Harrison. Commander and Director of WES during these tests and preparation of this report was COL Tilford C. Creel, CE. Technical Director was Mr. Fred R. Brown.

This report should be cited as follows

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CONTENTS

CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENT

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	0.0254	metres
pounds per square inch (psi)	6894.757	pascals

SITE CHARACTERIZATION FOR SMOKE WEEK III BATTLEFIELD OBSCURATION TESTS AT EGLIN AIR FORCE BASE, FLORIDA

PART I: INTRODUCTION

Background

1. A number of major field experiments have been conducted by the U. S. Army in recent years for the purpose of testing the performance of electro-optical-based weapons and surveillance systems under battlefield conditions. The environment of the battlefield is characterized by turbid atmospheres laden with particulates which degrade the performance of such systems, and accurate descriptions of the atmospheric obscurants are of interest to system designers, modelers, and users. A principal source for obscurants in the battlefield is the terrain as it is overturned and pulverized by traffic and munitions. The quality and quantity of dust produced by such activities is expected to be characteristic of the particular terrain conditions.

2. The U. S. Army Corps of Engineers (CE) has initiated a program to investigate the relation between terrain conditions and battlefield dust, with the objective of providing the Army with the capability to predict obscurant levels in potential battle areas for various levels of activity. Because of the lack of existing data on this subject, a substantial portion of that program has been devoted to an investigation of those terrain properties that are expected to control dust generation under these conditions. The field experiments conducted by other Army agencies have afforded opportunities to enhance this investigation with additional data, and thus, the U. S. Army Engineer Waterways Experiment Station (WES) has participated in several such tests.

3. The site characterization described herein is the second one performed for the Program Manager's Office for Smoke/Obscurants (PM-SMOKE). The terrain for the SMOKE Week II test series held at the same site in November 1978 was described in a letter report that is referred to where appropriate. This report benefits from the results

of that test as well as from WES participation in related tests at White Sands, New Mexico (the U. S. Army Atmospheric Sciences Laboratory (ASL), DIRT-II series), Fort Polk, Louisiana (joint tests between WES and ASL entitled DIRT-III), Redstone Arsenal, Alabama (the MICOM-PM AAH/HELLFIRE validation test series), and the CE-sponsored work at WES. The procedures used to obtain this characterization have evolved as understanding of the dust generation mechanisms of explosions has grown through these tests.

Purpose and Scope

4. The purpose of this work was to provide support to PM-SMOKE in the recent SMOKE Week III (SW III) test series conducted 11-22 August 1980 at Eglin Air Force Base (AFB), Florida. The objective of that effort was to evaluate the performance of electro-optical systems under battlefield conditions. The purpose of WES support was to provide site characterization and suitable terrain data and descriptions for analyzing the optical obscurants encountered during the test. The work is complementary to ongoing efforts at WES in battlefield environment parameterization initiated by the Office, Chief of Engineers (OCE), in Fiscal Year 1980.

5. The scope of this characterization covers those aspects of the terrain and soil which are expected to influence electro-optical propagation at visible, infrared, and submillimetre wavelengths. The WES role was to provide data useful in determining the amount and nature of the materials ejected from explosion craters and suspended temporarily in the atmosphere. That role included terrain and vegetation assessment, soil and crater measurements at the site, collection of soil samples for laboratory analysis, and assimilation and documentation of the results. This report presents and summarizes the results of that characterization.

6. Because useful relations between atmospheric loading and high explosives (HE) are not available, the terrain surface descriptors that pertain most directly to debris cloud character are not clearly defined. The criteria for terrain characterization used in this report have been

based on present understanding of explosive cratering dynamics and on soil and vegetation properties that are hypothesized to influence the formation of debris clouds.

PART II: SITE CHARACTERIZATION

Site Description

7. The site of the SMOKE Week III test was the same one used for the SMOKE Week II test, except that the optical path was realigned and vegetation cover was not removed. It is located at Test Range C52A on the eastern portion of Eglin AFB. The site occupied a relatively level area with about 50 percent coverage of grasses and forbs. Figure 1 illustrates the terrain and surface conditions found at the site.

8. The site comprised a 190-m-long by 340-m-wide plot divided equally across its width into a north and a south section. Each section had been gridded for the high-explosives tests into three rows 10 m apart, beginning 70 m from the plot's center line; the first and third rows contained 17 sampling stations 20 m apart, the second row contained 16. Seventy-two of these 100 stations were sampled at different times and depths during the 11-22 August period to determine moisture content, 70 of these to determine cone index, 63 to determine densities, 20 for particle size distribution, and 7 for organic content of the soil; crater measurements were made at 8 stations (see Figure 2 for grid plot).

9. The soil is uniform sand throughout the area. The surface layer has a higher organic content and a grayish color. At the 15-cm depth there is yellowish sand with low organic content. The soil was not compacted but was of medium density, with an average moisture content of less than 9 percent.

10. During the 2-week test period, rain occurred daily throughout the entire first week. This resulted in near-saturation of the soil much of the time and some changes in the test schedule. Drainage of the soil was good, however, and return to moderate conditions usually occurred in 12 to 24 hours. Meteorological data were obtained by the ASL and are available from PM-SMOKE.

Description of the Measurements

11. This site characterization is composed of a general site description and measurements of those soil properties hypothesized to be related to atmospheric loading of obscurants (see Appendix A). The specific soil parameters of interest and their methods of determination are as follows:

a. Cone index (CI): Made by pressing a calibrated metal cone into the soil, this measurement yields information that can be related to its shearing properties and bearing strength. The measurement is made on the site and consists of recording the force required to penetrate the soil with the cone at successive 5-cm intervals to a depth of 45 cm. Typically, two or three soil measurements are obtained at each sample point and the results averaged.

b. Size gradation: Obtained from bulk samples, this property is essential because it describes the raw material from which obscurants are formed. It is obtained by passing soil samples through calibrated screens or sieves of successively finer mesh and weighing the material retained on each. Material passing the No. 200 sieve (0.074-μm diam) is graded by means of a hydrometer. The results are presented in the form of a graph of the percentage by weight of material smaller than the selected diameter (percentage fines).

c. Mineralogy: The mineral content of the soil allows the inference of its optical properties, providing the minerals have been so measured in bulk form. It is obtained by means of x-ray diffraction spectroscopy.

d. Organic content: Organic matter alters the mechanical as well as optical properties of the soil. Organic content is measured in the laboratory by weighing the bulk material before and after heat processing.

e. Atterberg limits: These refer to the liquid and plastic limits (LL and PL) of the material and are expressed as moisture contents. They are obtained by testing samples of the soil of varying moisture contents in the laboratory to establish the values at which it exhibits liquid and plastic properties according to prescribed criteria. A related parameter that is useful is the plasticity index (PI) which is the difference of the two limits. Atterberg limits are obtained by using a simple laboratory test procedure.

f. Moisture content: The amount of moisture in the soil expressed as a percentage of its dry weight. It is an

essential part of all electro-optical (EO) characterizations, and its variability with time and weather must be considered. Moisture content can be measured in the field or in the laboratory by using gravimetric techniques.

g. Wet unit weight: This is density of wet bulk material, including voids (air spaces), and figures in calculations of ejecta. Bulk density can be estimated by simple gravimetric techniques in the field.

h. Specific gravity: This is the average density of the solid soil material excluding water and voids. Dry density is computed by using the values of bulk density and moisture content.

12. Bulk soil samples were obtained in two ways. Samples to determine volume-related properties, such as moisture and density, were obtained with a Hvorslev core sampler. Samples for laboratory analysis of characteristics such as grain size distribution and mineralogy were obtained by using a shovel or with the Hvorslev sampler (for samples at significant depths below the surface). These samples were returned to WES for analysis.

13. Crater measurements consisted of the apparent depth below original surface and diameter in two transverse directions at the level of the original surface. In addition, the depth of powdered material in the crater was measured.

14. Vegetation was characterized by determining the types of vegetation, the density of root structures, and the amount of surface cover. Site photographs (see Figure 3) were taken to assist in documenting conditions, but weights of roots and foliage were not obtained. Two plots of 1 m square were selected for study. Plants were removed from them individually for counting and identification. Nine different species were tentatively determined to be representative of the herbs and forbs. Larger vegetation such as *Yucca* and *Baccharis* were not included because these were generally avoided in the placement of the explosives. The nine types and their descriptions (including genetic name if it could be determined) are shown in the tabulation below.

Type	Quantity, stems/m^2	Description and Tenative Identification
1	6	Tall, coarse grass
2	11	54 short leaf, clumped, jointed (? *Panicum*)
3	4	Tall, woody
4	9	Short leaf
5	32	Thin, long-leaved grass (? *Panicum*)
6	110	Red-stemmed (? *Hypericum*)
7	7	Small broadleaf succulent
8	20	? *Euphorbia*
9	2	Broadleaved vine (not illustrated)

PART III: DATA RESULTS

15. The measured soil data are presented in Tables 1 and 2, and the crater dimensions appear in Table 3. The moisture content and density show little variation throughout the site. Average values and standard deviations (in parentheses) for the site are summarized in the following tabulation:

Data Type	Measurement (Standard Deviation)
Mean moisture content at surface	4.92 percent (2.21)
Mean wet density at surface	1.53 gm/cm^3 (0.08)
Mean dry density at surface	1.46 gm/cm^3 (0.07)

Individual station moisture content values are also shown in Figure 3.

16. Cone index was measured at each station (Figure 3). The average cone index measurement at the 0- to 15-cm layer was 221; the average at the 15- to 30-cm layer was 464; and the average at the 30- to 45-cm layer was 489. These values are generally higher than those observed during SW-II. Cone indexes near craters appeared no different from those farther away. Crater locations are shown in Figure 3.

17. The gradation curves (Figures 4-23) contain the sieve analysis data of samples collected from the various station locations as shown in the figures. All samples were classified as sand (SP-SM) with color variation due to the organic content. Generally, soil free of organic matter was yellow to light tan, and increased organic content produced a dark gray color. In all samples the soil was nonplastic (NP). Organic content was measured for seven bulk samples and ranged from 0.5 percent to 2.7 percent (Table 2). As the curves of Figures 4-23 show, most of the material falls between 3.5 and 0.7 mm in grain size thus indicating a medium to fine sand. The hydrometer analysis was not performed on these samples because of the relatively low percentage of fines; i.e., the soil was a clean sand. For purposes of comparison to the soils of other such tests, the classification chart of Figure 24 is provided.

18. Analysis of the vegetation at Station 27 in the north portion showed 50 percent coverage by grasses, one percent broadleaved forbs, with the balance of the soil unvegetated sand. At Station 39 in the south portion there was also 50 percent coverage by various grasses and a few forbs; there were occasional yucca plants, while the rest of the ground was bare sand. The grasses and forbs were rhizomatous perennials with fibrous roots that tend to bind the soil. However, the vegetative cover was sparsely distributed across the sand surface, and there were no plant heights greater than 75 cm with the average being 25 cm. The effect of vegetation in reducing dust at this site is considered to be slight.

19. Eight craters were formed by high explosives. The diameters in both north-south and east-west directions were measured, as well as the apparent depth. Additionally, the depth of powdered material that had fallen back into the crater was measured and is shown in Table 3. This material is characteristic of sands. Apparent depth was measured from the visible bottom surface of the crater to the preblast surface level. Diameters were measured at the level of the preblast surface. In Table 4, the mean values are compared to those of SW-II.

20. Ejecta from the craters were measured by placing 22-cm pans at 5-, 10-, and 15-m distances from the expected crater center. Only two shots were measured in this manner (see Table 3). The mean density of the ejecta at 5 m was 3553 gm/m^2, at 10 m was 420 gm/m^2, and at 15 m was 113 gm/m^2.

PART IV: SUMMATION

Discussion

21. The nonplasticity of the soil at Eglin AFB and resulting lack of cohesive strength provide for facile separation of soil particles by mechanical forces such as those that accompany explosions. This situation is conducive to dust production. However, it is offset by the absence of an appreciable amount of material in the dust particle size range, a characteristic of sands.

22. It has been observed that in sands under blast loading there is an appreciable production of dust-size particles (sand flour) as a result of the fracturing of larger grains. At present there is no means for estimating the quantity of such dust produced, but the tests at Eglin revealed substantial amounts in the bottoms of the craters. This would suggest that the potential for dust creation in sandy areas might increase with the duration of battle activities and with multiple explosions.

23. Since moisture content measurements were interrupted by rainfall, the values shown on the grid in Figure 2 cannot be directly compared; i.e., isopleths cannot be drawn. Some measurements were repeated as a result of rainfall and in response to test condition and schedule changes. In some cases moisture content was determined by more than one method, yielding more than one value. Not all values are shown on the grid in Figure 2 due to space limitations. Such comparisons can be made after suitable hydrologic adjustment, given the times and amounts of rainfall in addition to some drainage data for the site. Such analysis falls outside the scope of this effort. The moisture conditions that prevailed at the times of the HE dust tests are expected to vary downward from 8 percent depending on the length of time after the last precipitation. The higher values observed (8-9 percent), while low in comparison to conditions attained in silts or clays as at DIRT-II and -III (Miller 1979, Mason and Long 1981), are high for sands and can be expected to indicate a substantial degree of dust suppression.

24. The CI data revealed no evidence of a hardpan layer beneath the surface in contrast to SMOKE Week II results. This can be explained by the absence of the blading and associated heavy vehicle traffic which created the hardpan layer in the previous test. Its effect on dust production is not known at present. There is evidence (Piekutowski 1977) that subsurface layers of harder material appear to add to the ejection of soil by reflecting the downward propagating shock wave. Such an effect may be appreciable only for sharp interfaces, but in any event would not be present here.

25. The density of soil has been observed to affect the angle at which material is ejected as well as the resultant crater volume (Andrews 1977). The observed mean dry density at SW III of 1.46 gm/cm^3 is relatively low for sand; because of this it may be expected that a substantial portion of crater volume is due to compaction, the exact amount depending on the degree of saturation at the time of the explosion. Observed saturations ranged from 4.5 to 33 percent, the latter representing the highest moisture contents observed. Based on the very limited information available, it is estimated that under the driest conditions observed as much as 50 percent of crater volume may have been due to compaction and under the wettest, possibly 30-35 percent.

Conclusion

26. In conclusion, the site at SW III is characterized as consisting of a homogeneous, poorly graded sand of moderate to low density having a fine fraction of less than 7 percent. The color is yellow to reddish at depth, changing to white at the surface and stained to gray by organic matter in the subsurface layer (A-horizon). Observed moisture contents during the test period ranged from moderate (2.3 percent) to high (8-9 percent) for sands and were modified daily by precipitation during the first week of tests. Permeability of the soil was high, and drainage was good.

27. Vegetation cover provided the most significant change from conditions at SW II. Surface coverage by active plants was 50 percent,

but much of the bare surface was covered by litter. Root structure was, for the most part, fragile and root density moderate to low. (As a basis for comparison, root density was measured in a dense Bermuda grass sod and was found to be 160,000 roots/m^2. The vegetation cover at the SW III site was estimated to be one-tenth of that, or 16,000 roots/m^2.) Organic content of the soil (between 0.5 and 2.7 percent) was comparable to that of SW II.

28. The overall dust potential of this soil is judged to be very low, although compared to heavier sands it may be slightly higher based on the amount of sand flour observed. Its dust potential would be expected to increase somewhat with continued mechanical activity.

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Table 1

Moisture Content and Densities

Station	Time	Moisture Content %	Wet Density gm/cm^3	Dry Density gm/cm^3	Depth cm
		12 Aug 80			
7S*	1650	2.3	1.46	1.43	3-10
27S	1655	2.1	1.48	1.45	3-10
41S	1656	1.5	1.37	1.35	3-10
		13 Aug 80			
9N	0715	3.1	1.55	1.50	3-10
26N	0725	3.7	1.50	1.45	3-10
40N	0735	2.3	1.46	1.43	3-10
39N	0742	1.5	1.48	1.46	3-10
6N	0850	2.5	1.48	1.44	3-10
13N	0900	1.8	1.45	1.43	2-10
46N	1130	3.4	1.42	1.37	3-10
24N	1140	2.0	1.41	1.38	3-10
14S	1150	1.6	1.47	1.44	3-10
20S	1200	2.2	1.46	1.43	3-10
45S	1215	2.2	1.45	1.42	3-10
48S	1230	1.7	1.31	1.29	3-10
48S	1235	3.4	1.51	1.47	43-50
		14 Aug 80			
5S	0705	2.1	1.50	1.47	3-10
29S	0712	2.5	1.49	1.45	3-10
39S	0718	1.9	1.44	1.41	3-10
37S	0730	2.0	1.54	1.51	3-10
31S	0735	2.2	1.41	1.38	3-10
3S	0740	3.5	1.30	1.26	3-10
4N	0800	3.1	1.50	1.46	3-10
31N	0805	3.6	1.57	1.52	3-10
36N	0810	3.4	1.49	1.45	3-10
34N	0820	2.7	1.47	1.43	3-10
33N	0825	3.9	1.51	1.45	3-10
2N	0830	2.7	1.51	1.47	3-10
29N	0837	1.8	1.39	1.37	3-10
43N	0845	2.4	1.40	1.36	3-10
11N	0850	2.8	1.55	1.51	3-10
22N	1010	2.7	1.39	1.35	3-10

(Continued)

* See Figure 3 for location of station on south (S) or north (N) half of sampling grid.

Table 1 (Continued)

Station	Time	Moisture Content %	Wet Density gm/cm^3	Dry Density gm/cm^3	Depth cm
		15 Aug 80			
9S	0730	8.5	1.71	1.58	3-10
25S	0737	6.7	1.55	1.45	3-10
43S	0742	7.3	1.64	1.53	3-10
23S	0748	7.3	1.64	1.53	3-10
11S	0754	7.7	1.59	1.47	3-10
16S	0800	8.8	1.54	1.41	3-10
18S	0806	9.0	1.66	1.52	3-10
50S	0811	8.4	1.54	1.42	3-10
1S	0900	8.0	1.54	1.43	3-10
		17 Aug 80			
17N	0925	5.6	1.54	1.46	3-10
18N	0931	5.4	1.56	1.48	3-10
50N	0935	4.2	1.50	1.44	3-10
49N	0940	4.9	1.49	1.42	3-10
19N	0945	5.7	1.54	1.46	3-10
12N	1032	6.2	1.52	1.43	3-10
16N	0951	6.8	1.61	1.51	3-10
15N	0956	7.1	1.52	1.42	3-10
20N	1002	6.0	1.58	1.49	3-10
48N	1010	7.0	1.61	1.51	3-10
14N	1019	8.0	1.56	1.45	3-10
44N	1045	5.9	1.49	1.41	3-10
30N	1215	6.2	1.62	1.53	3-10
27N	1225	5.8	1.63	1.54	3-10
32N	1210	7.3	1.63	1.52	3-10
30S	1152	6.7	1.60	1.50	3-10
28N	1220	7.2	1.65	1.54	3-10
26S	1145	7.1	1.65	1.55	3-10
28S	1147	6.1	1.64	1.55	3-10
24S	1137	6.5	1.72	1.61	3-10
32S	1156	7.5	1.53	1.42	3-10
33S	1203	7.4	1.57	1.46	3-10
21S	1116	7.9	1.69	1.57	3-10
23N	1040	6.8	1.64	1.53	3-10
19S	1120	5.9	1.55	1.46	3-10

(Continued)

Table 1 (Concluded)

Station	Time	Moisture Content %	Wet Density gm/cm^3	Dry Density gm/cm^3	Depth cm
47N	1023	8.1	1.57	1.45	3-10
12S	1059	5.1	1.60	1.52	3-10
46S	1110	6.5	1.55	1.46	3-10
21N	1029	8.2	1.62	1.49	3-10
22S	1103	6.6	1.60	1.50	3-10
		20 Aug 80			
28S	1240	6.1	1.68	1.58	3-10
6N	1235	3.6**	--	--	0-10
6N	1145	3.5**	--	--	0-10
28S		4.1**	--	--	0-10
11S	1242	7.2**	--	--	0-10
12N	1245	4.0**	--	--	0-10
		21 Aug 80			
6N	0920	3.9**	--	--	0-10
11S	1205	6.7**	--	--	0-10
28S	1004	5.6**	--	--	0-10
12N	1200	4.5	1.56	1.49	3-10
11S	1205	3.4	1.47	1.42	3-10
28S	1207	7.8	1.62	1.50	80-90
8N	1200	3.9	1.52	1.46	3-10
12N	1202	4.5	1.56	1.49	3-10
11S	1205	6.6	1.47	1.38	3-10
28S	0945	6.1	1.68	1.58	3-10

** Moisture content determined with Speedy Moisture Tester.

(Sheet 3 of 3)

Table 2

Organic Content

Station	Depth cm	Organic Content %
7S*	3-10	1.0
16S	3-10	1.3
19N	3-10	1.3
22N	3-10	2.7
28N	3-10	1.3
48N	47-53	1.5
25N	60	0.5

* See Figure 3 for location of station on south (S) or north (N) half of sampling grid.

Table 3

Summary of Crater Measurements

Station	Diameter, cm N-S	Diameter, cm E-W	Depth cm	Depth of Fallback Material, cm	Mean Density of Ejecta at Distances, g/m^2 5 m	10 m	15 m
25N*	150	150	44	8			
44N	140	135	36	6			
12N	160	130	38	10			
26N	150	160	44	6			
40N	135	130	39	6			
41S	240	250	35	8	3525	316	110
39S	245	250	50	10			
38S	215	220	55	10	3582	525	116

* See Figure 3 for location of station on south (S) or north (N) half of sampling grid.

Table 4

Comparison of Crater Results

Charge Weight kg	Test Series	Mean Diameter (D) m	Mean Depth (d) m	Volume Parameter (dD^2) ln
2.27	SW II	1.46	0.53	0.122
	SW III	1.44	0.40	0.187
6.8	SW II	2.18	0.66	1.14
	SW III	2.37	0.47	0.971

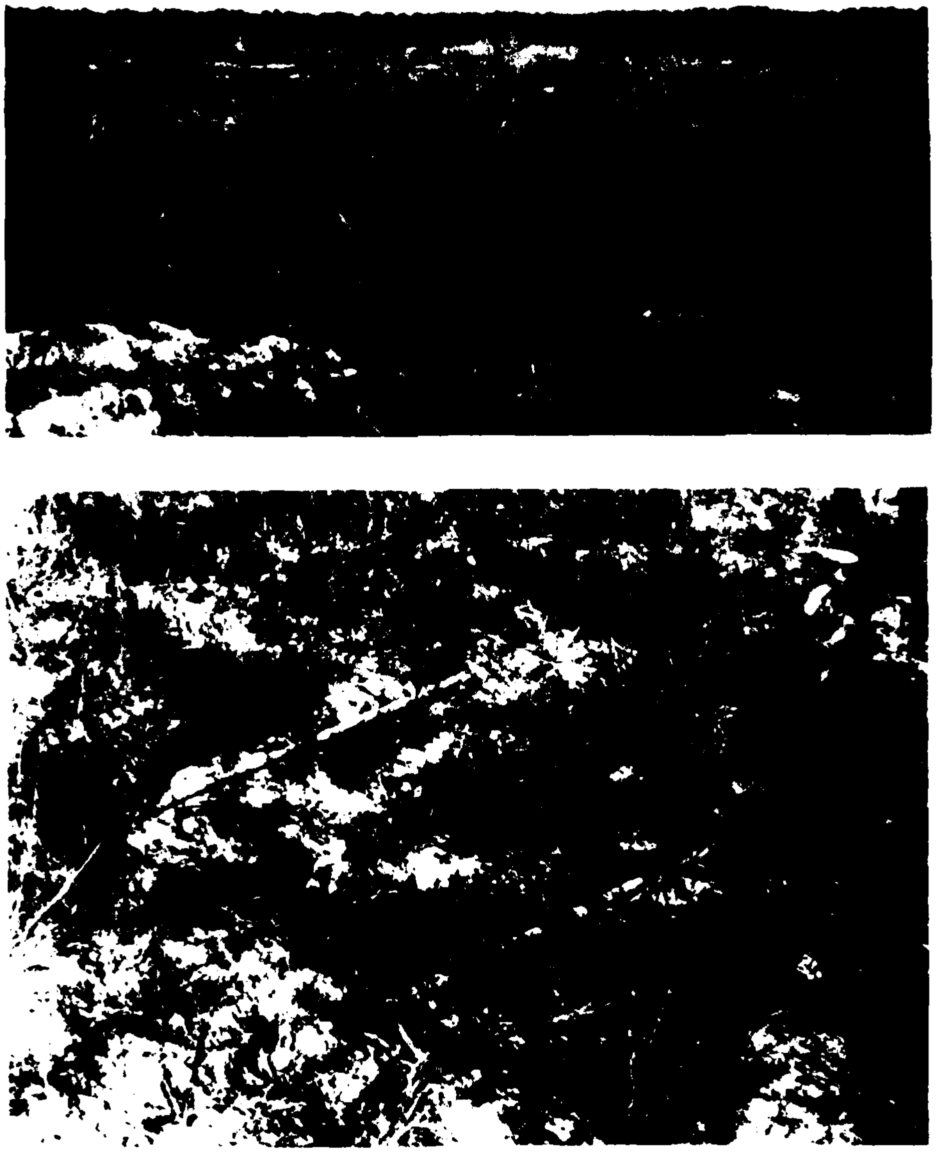


Figure 1. Terrain and surface conditions typical at the site of the SMOKE Week III test at Eglin AFB, Florida, 11-22 August 1980

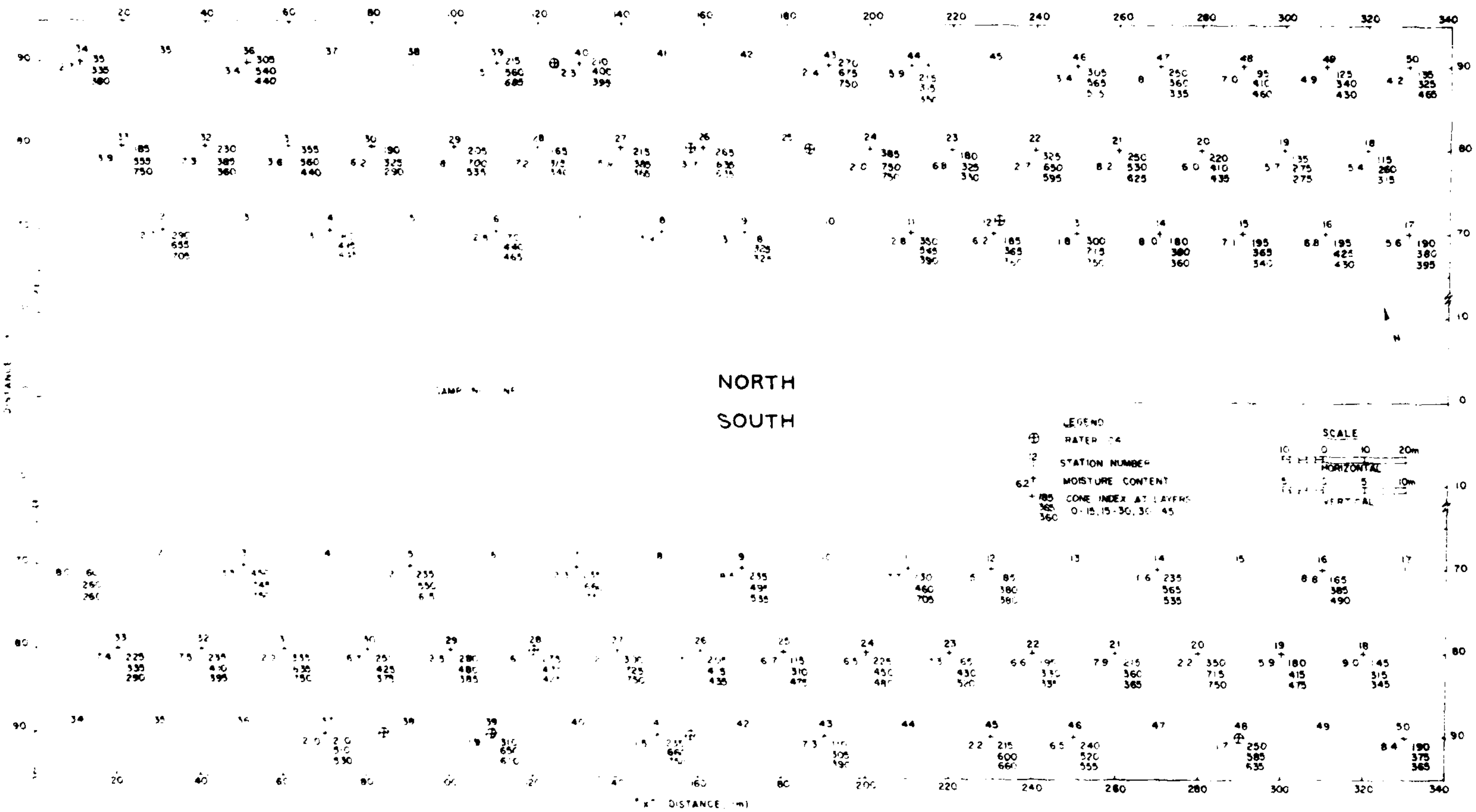


Figure 2. Sampling grid of the SMOKE Week III site showing the distribution of cone index and moisture content values and the location of craters

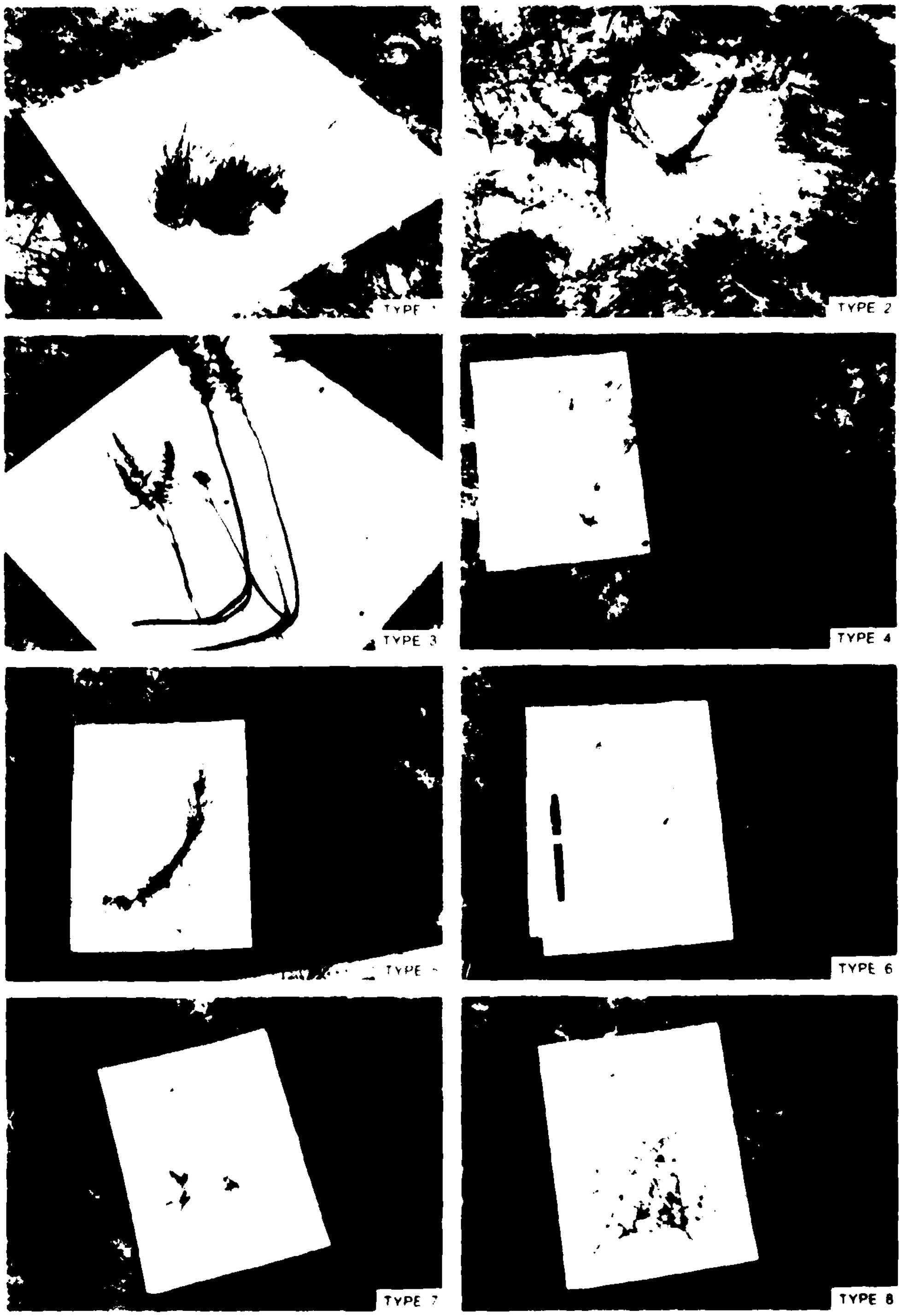
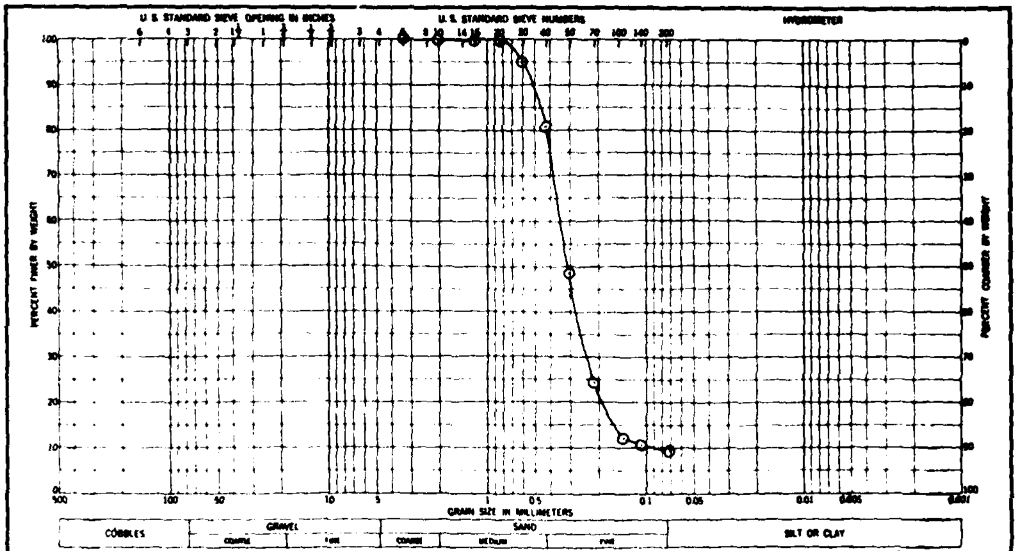


Figure 3. Vegetation types observed at the SW III test site. The type numbers correspond to those given on page 7



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
15 N	3 - 10 cm	SAND, SP-SM		NP		

GRADATION CURVES

Project SMOKE WEEK III
EGLIN AFB, FL
Area NORTH PORTION
Boring No
Date 17 AUG 80

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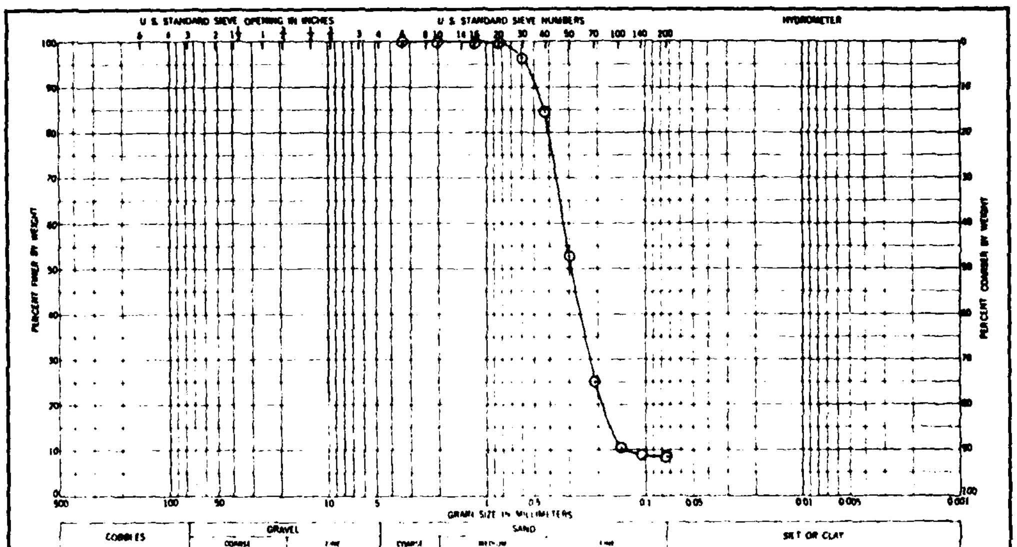
Figure 4. Particle size distribution of sample taken from location 15N



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
23 N	3 - 10cm	SAND, SP-SM		NP		

GRADATION CURVES

Project SMOKE WEEK III
EGLIN AFB, FL
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Boring No
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Figure 5. Particle size distribution of sample taken from location 23N

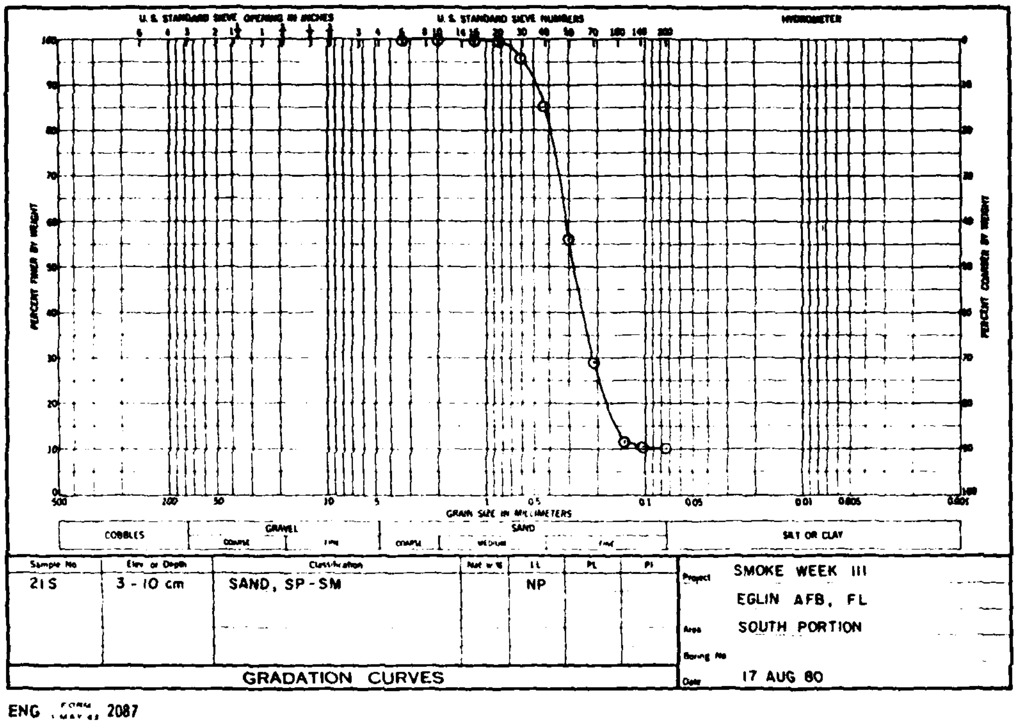

Figure 6. Particle size distribution of sample taken from location 21S

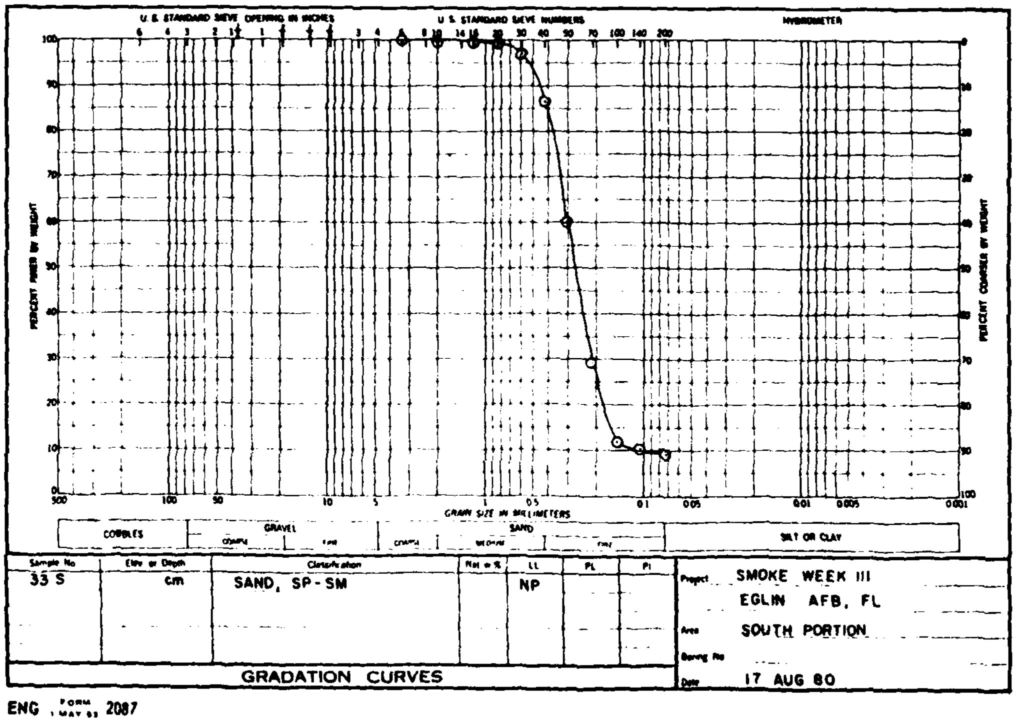

Figure 7. Particle size distribution of sample taken from location 33S

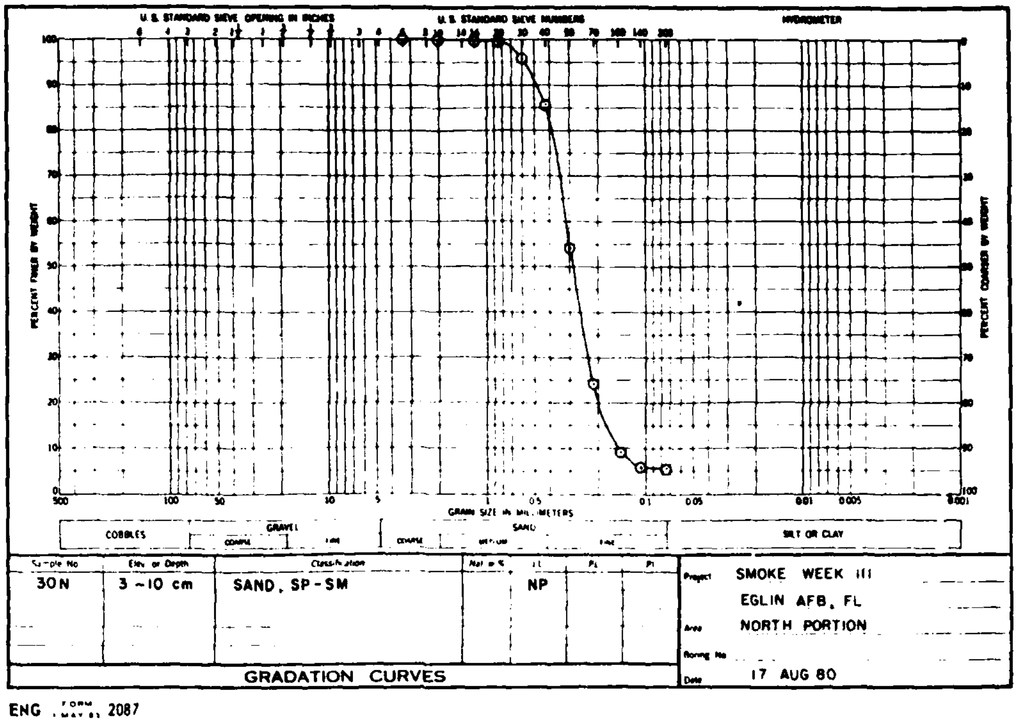

Figure 8. Particle size distribution of sample taken from location 30N

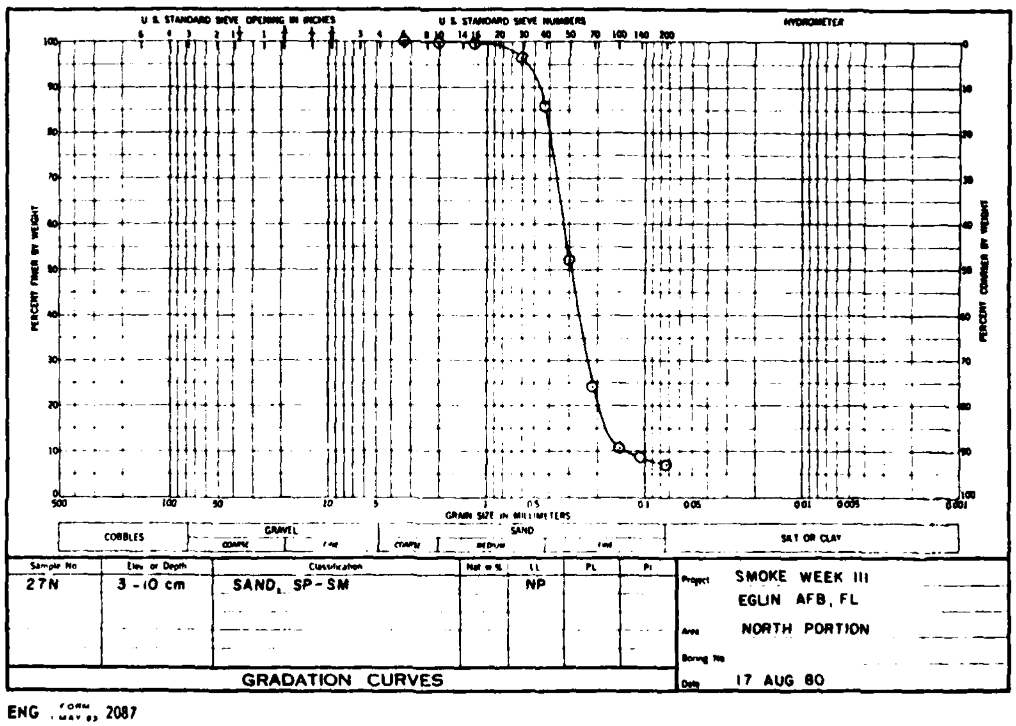

Figure 9. Particle size distribution of sample taken from location 27N

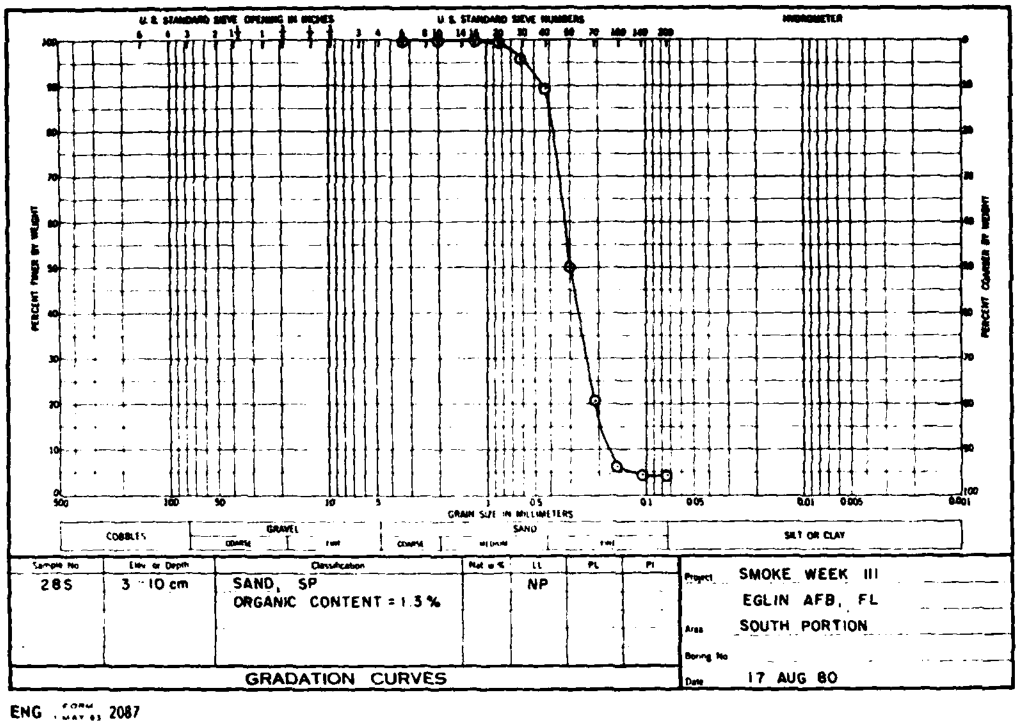

Figure 10. Particle size distribution of sample taken from location 28S

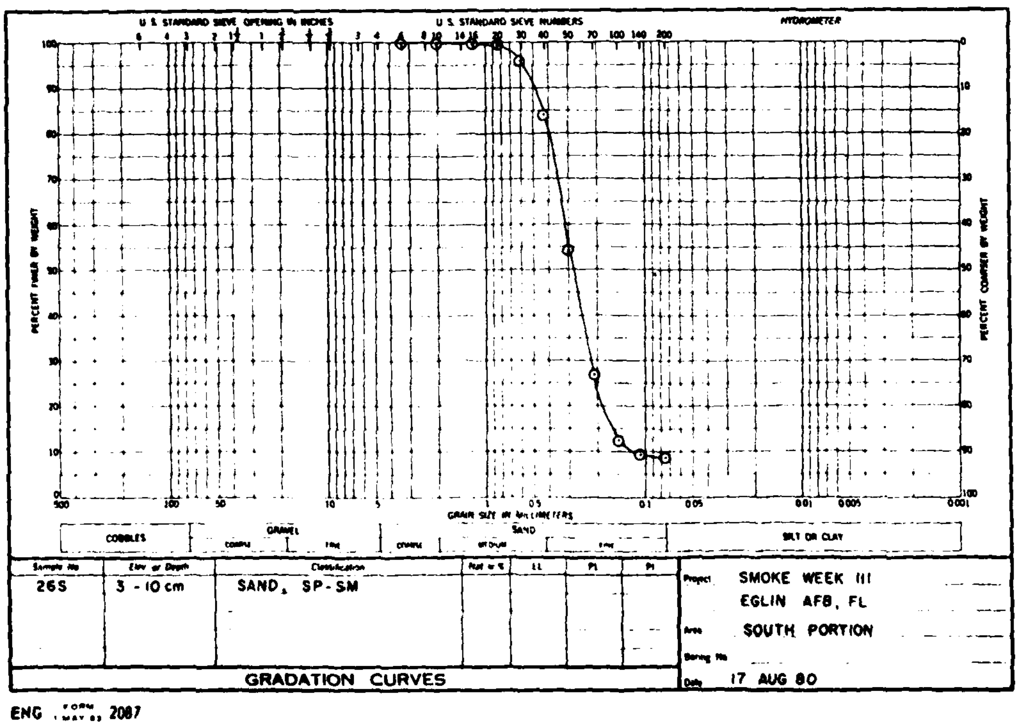

Figure 11. Particle size distribution of sample taken from location 26S

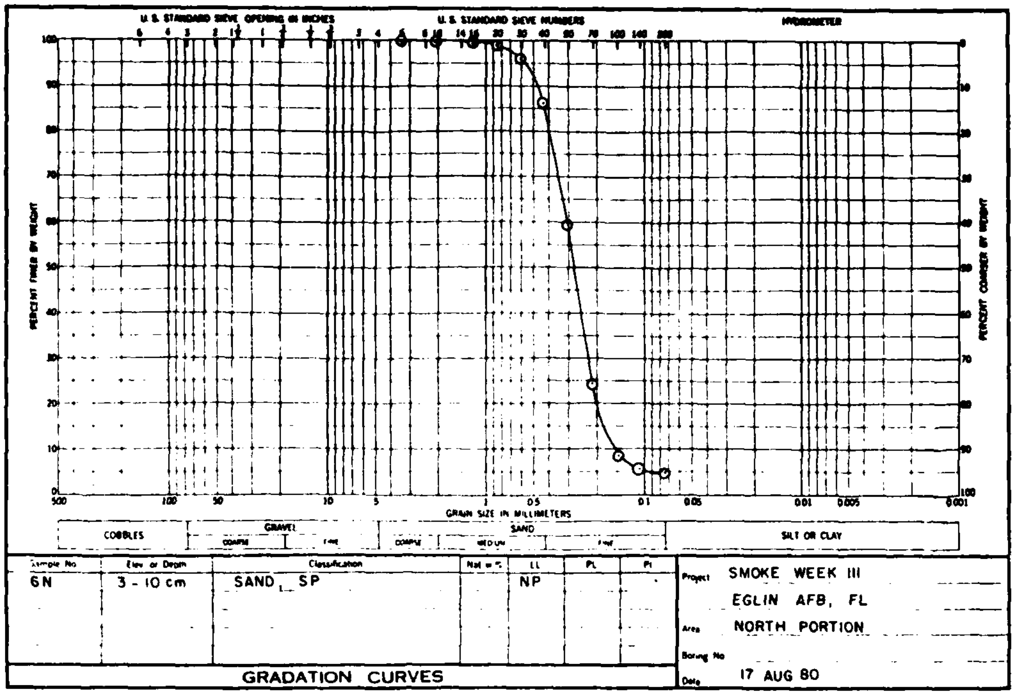

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Figure 12. Particle size distribution of sample taken from location 6N

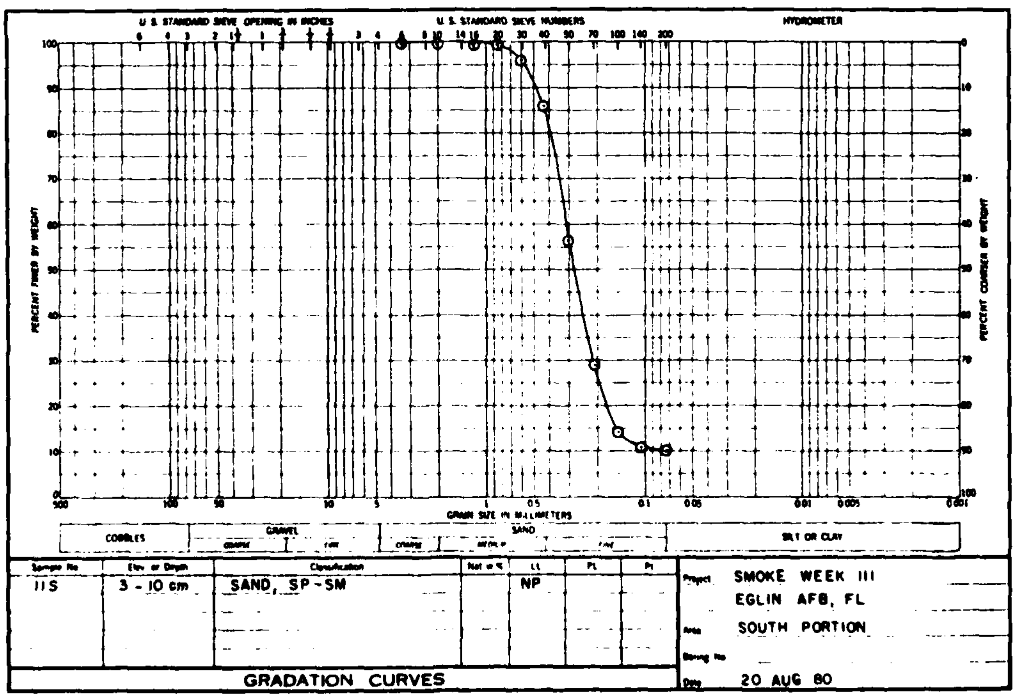

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Figure 13. Particle size distribution of sample taken from location 11S

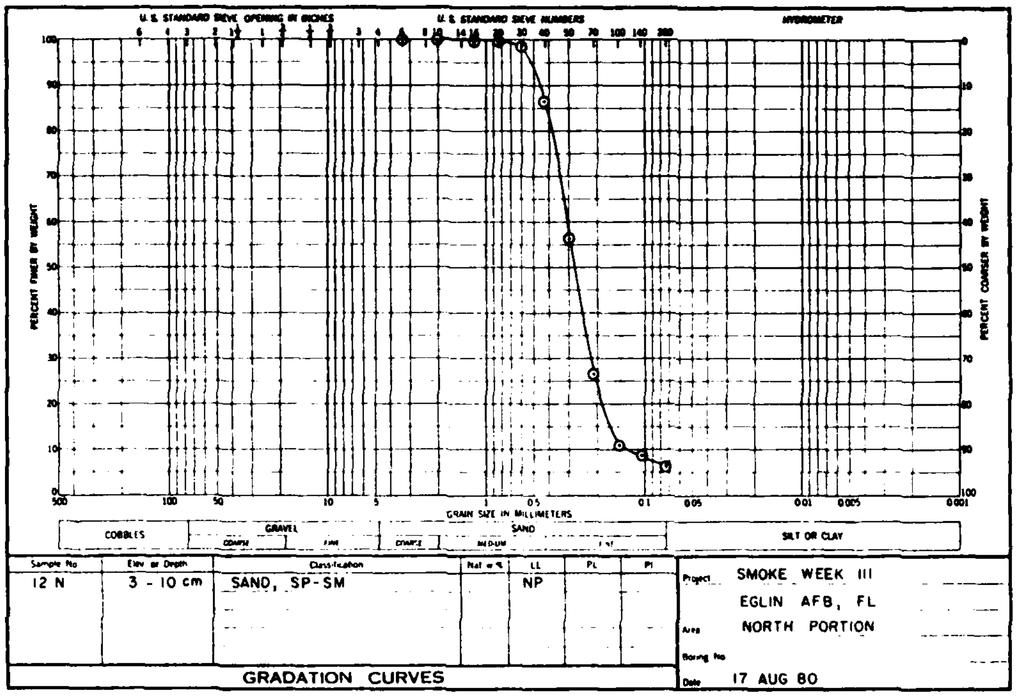

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Figure 14. Particle size distribution of sample taken from location 12N

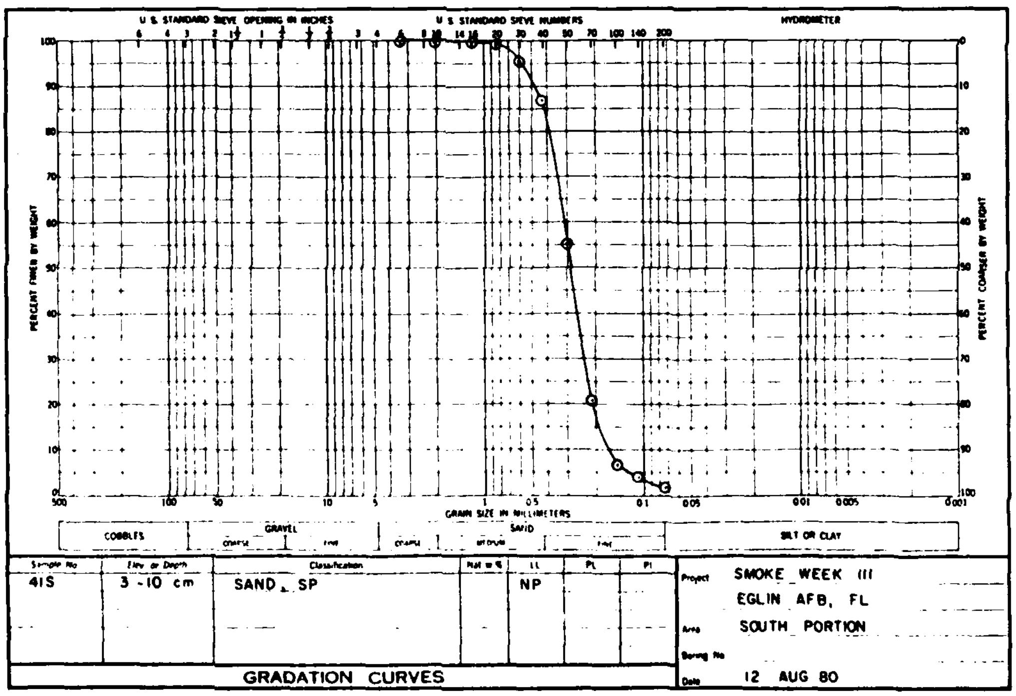

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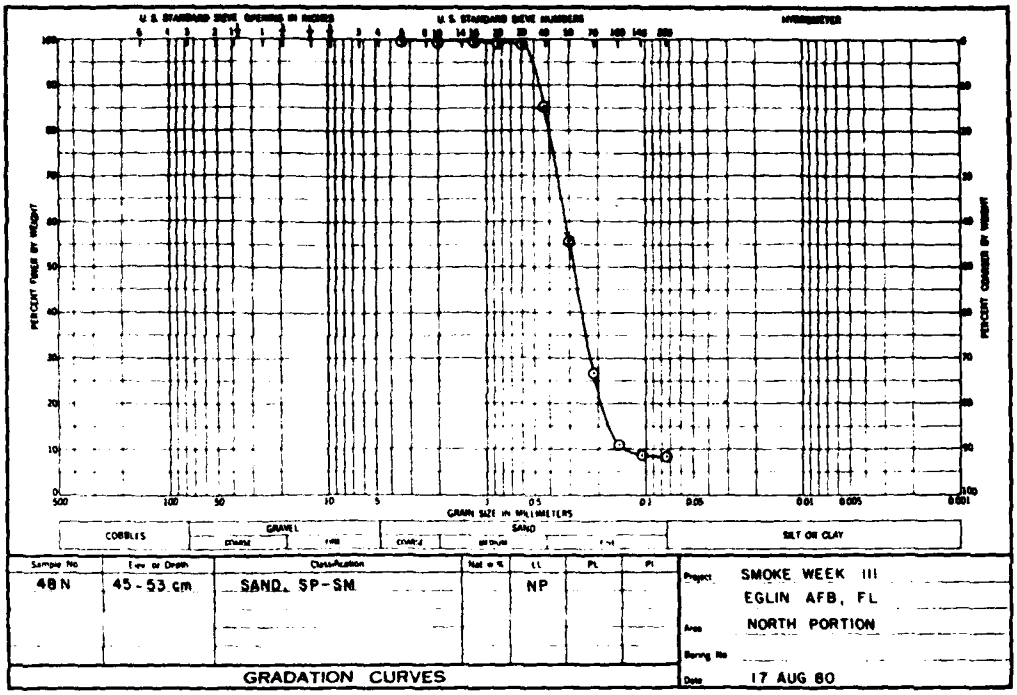
Figure 15. Particle size distribution of sample taken from location 41S



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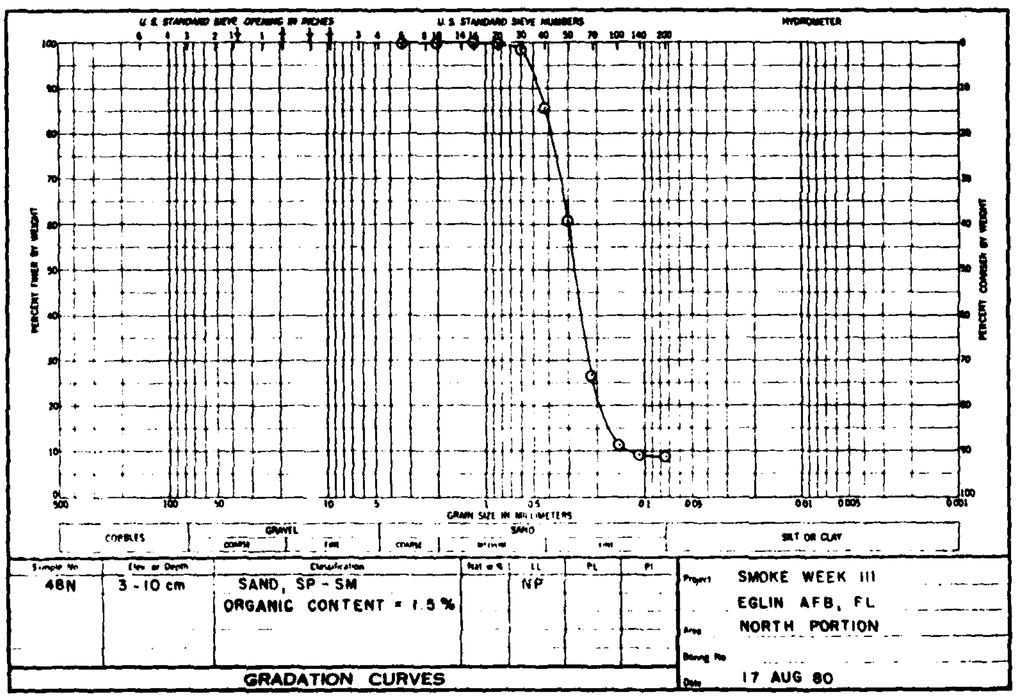
a. At 3-10 cm



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b. At 45-53 cm

Figure 16. Particle size distribution of samples taken from location 48N

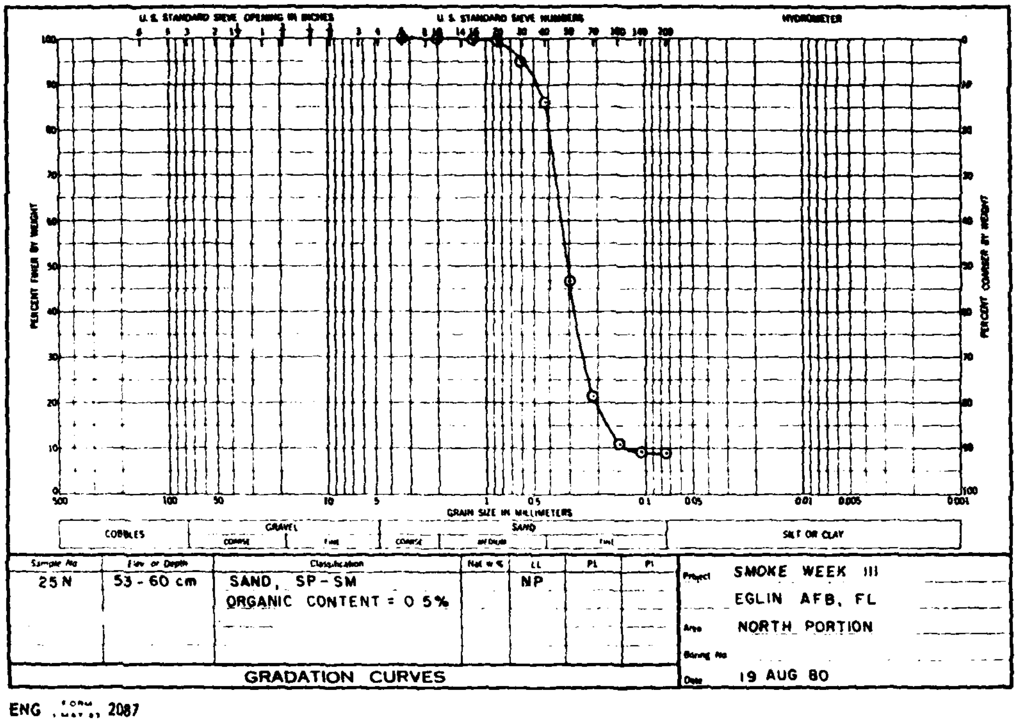

Figure 17. Particle size distribution of sample taken from location 25N

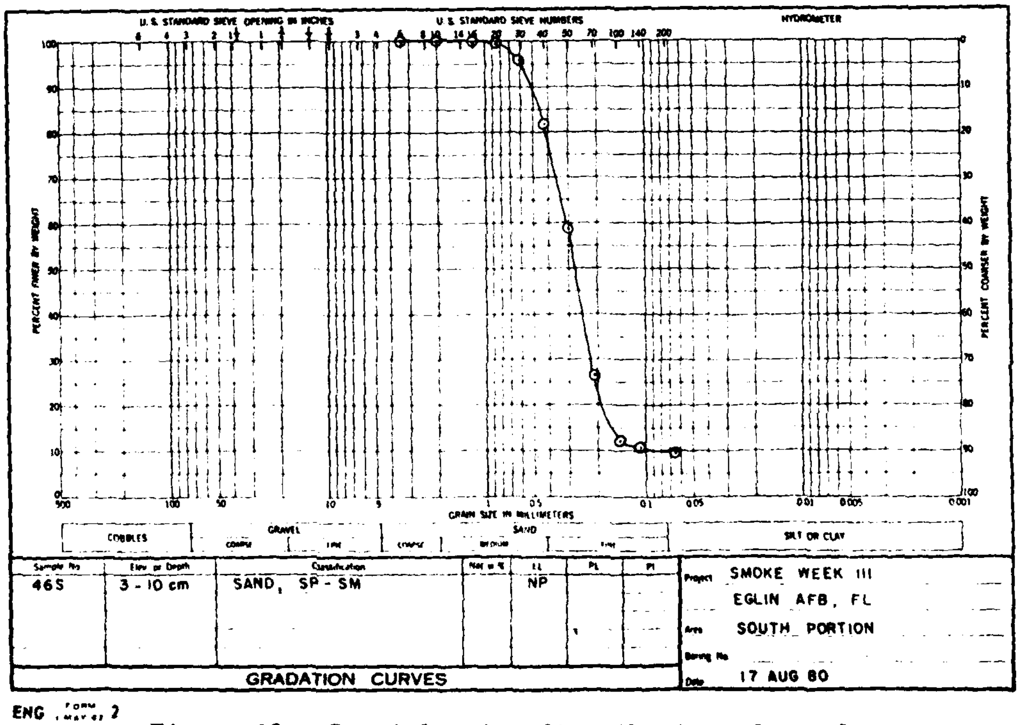

Figure 18. Particle size distribution of sample taken from location 46S

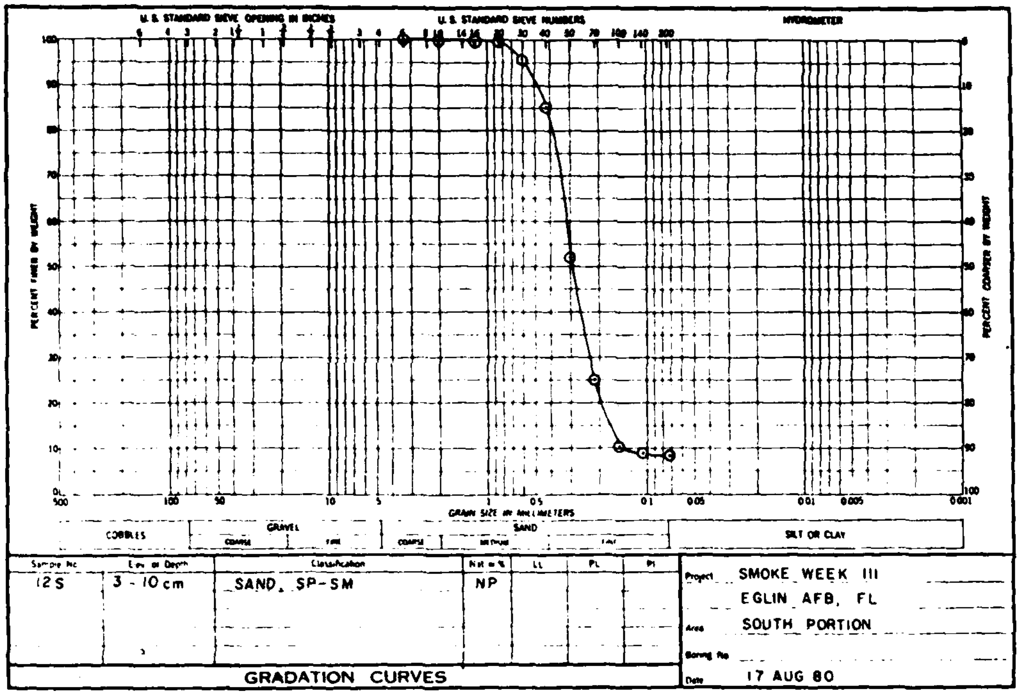

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Figure 19. Particle size distribution of sample taken from location 12S

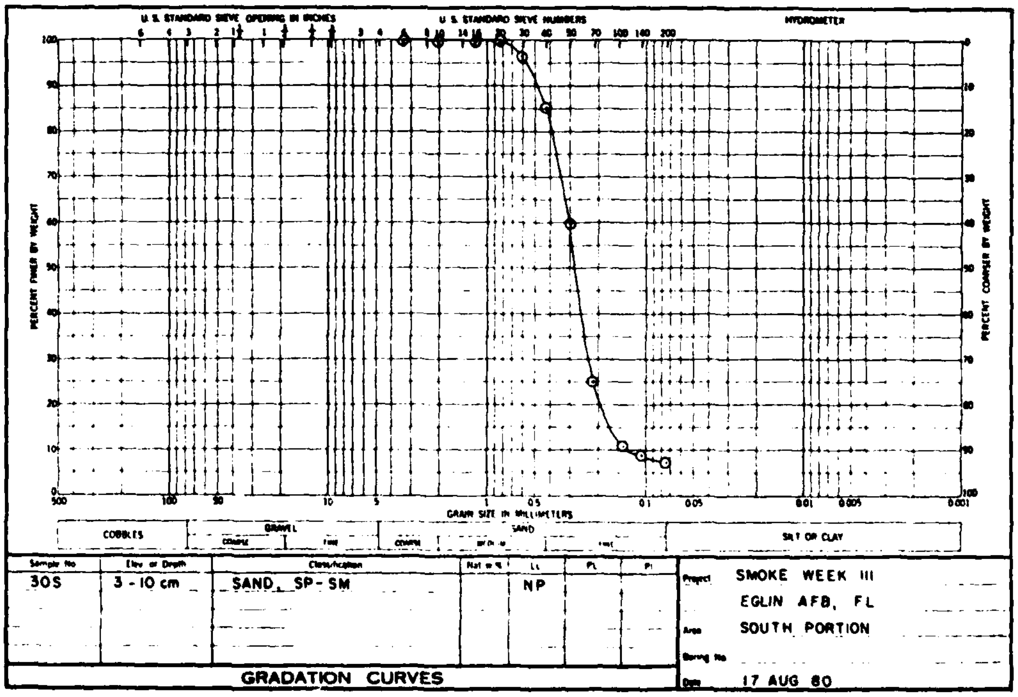

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Figure 20. Particle size distribution of sample taken from location 30S

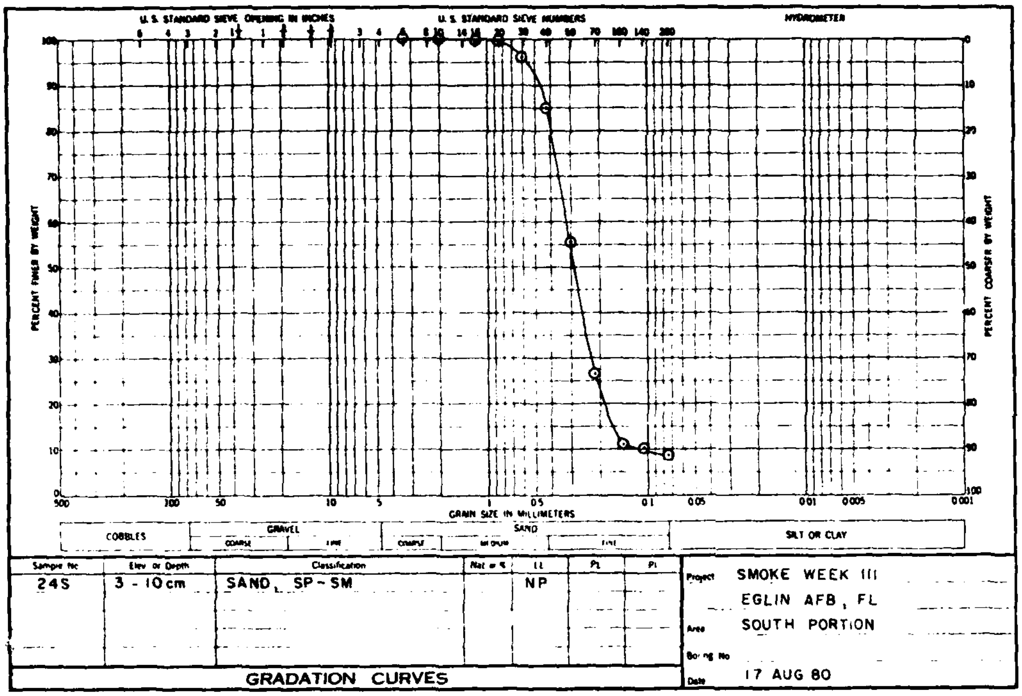

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Figure 21. Particle size distribution of sample taken from location 24S

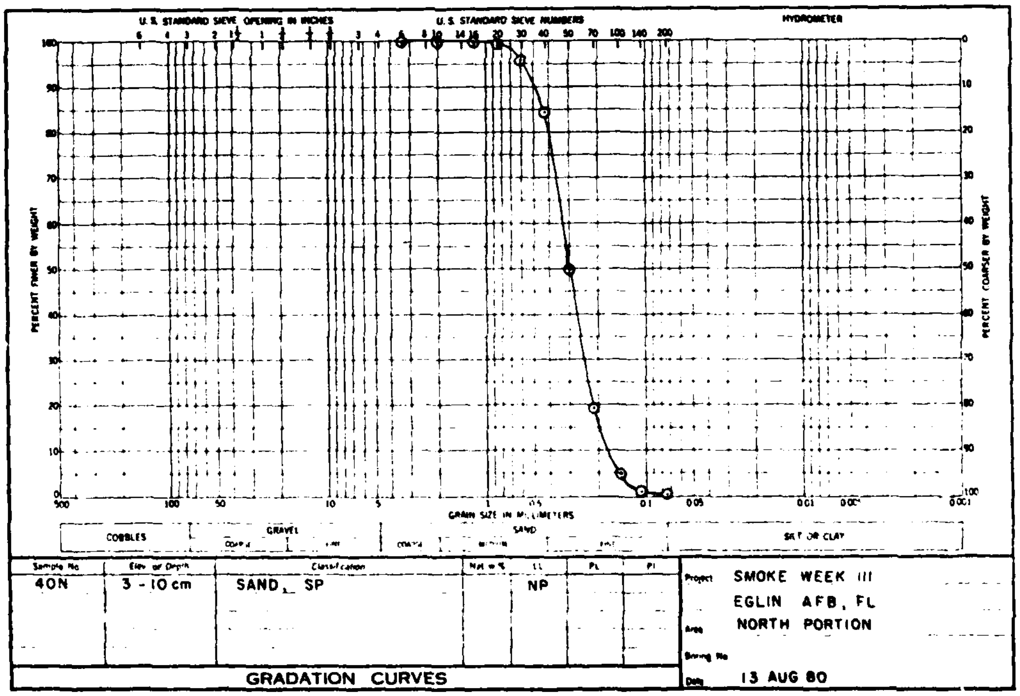

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Figure 22. Particle size distribution of sample taken from location 40N

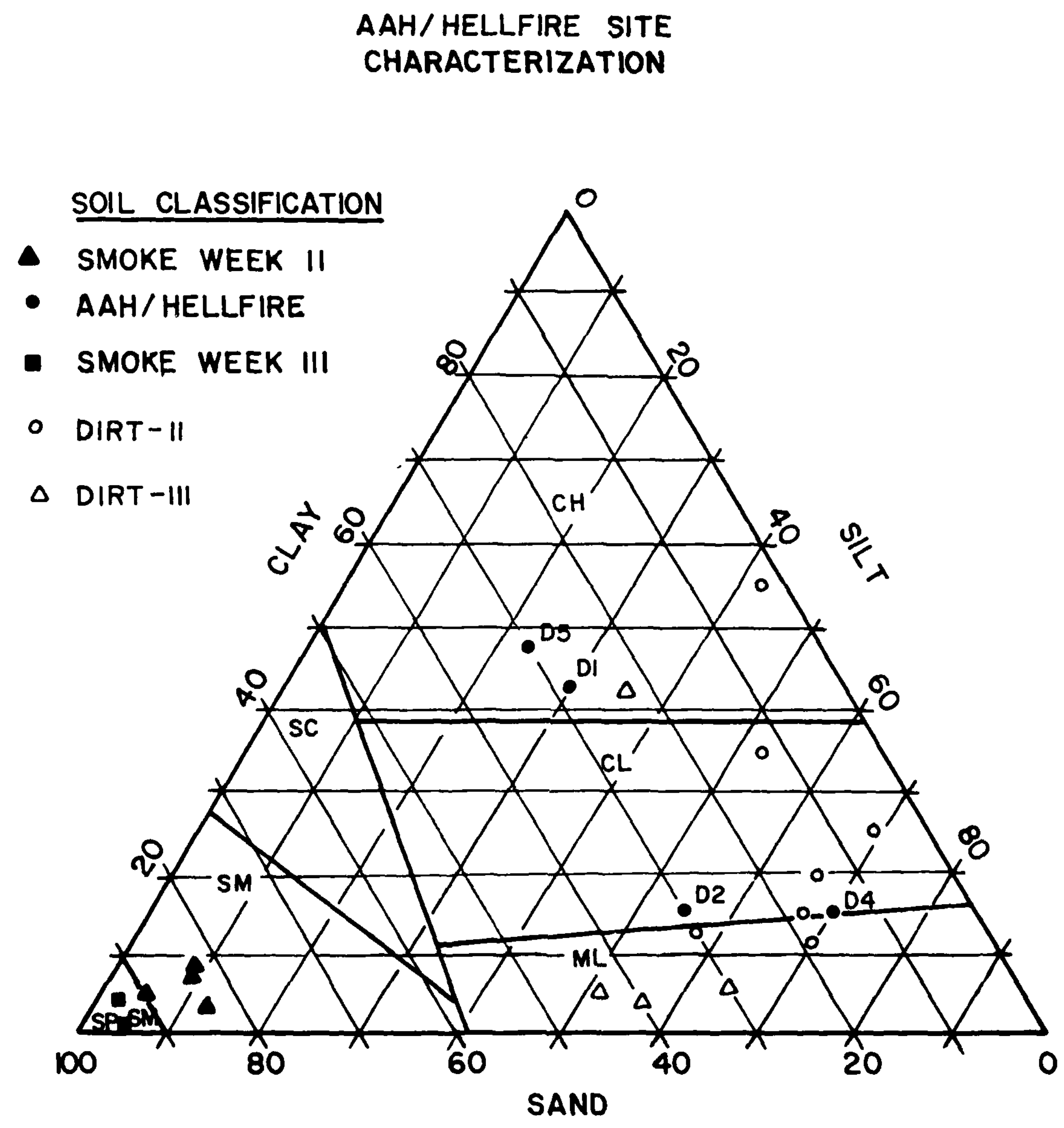

Figure 23. Soil classification triangle

APPENDIX A: SITE CHARACTERIZATION PROCEDURE

Preliminary Observations

1. The purpose of preliminary observations is to make a general assessment of the terrain and climate conditions and to collect data of a general nature that may aid in planning tests as well as analyzing their results. What one is concerned with here are vegetation, drainage features, predominant soil features, and any unusual or anomalous features that may affect tests. These results should be consulted in the final selection of test points. Recommended observations for this part are briefly described below.

2. Visual and photographic observations of the site should focus on vegetation types, variety, and density. Surface conditions and variety should also be portrayed. When bare soil occurs in significant areas, its undisturbed condition as well as subsurface structure should be photographed or documented. Sod depth and root density can be documented by cutting a trench with a spade in vegetated areas and photographing the walls.

3. Terrain documentation should describe slope and landform in the test area, and the drainage features should be discussed in detail. Geologic structures such as rock outcrops in the test area or nearby sources of alluvial material should be identified.

Quantitative Data Collection

Soil measurements

4. Bulk samples. Bulk samples of the soil representative of the entire test area should be collected. Since dust originates primarily in the surface layer, these samples should be taken mostly from the 0- to 15-cm-depth stratum. If stratification with different soil types occurs, at least one sample should be obtained from each stratum down to 75 cm. Surface samples should include roots but not foliage or deadfall material.

5. Cone index (CI). Cone index measurements (U. S. Army Engineer Waterways Experiment Station 1962)* should be made at regular intervals throughout the test area. The instrument used is the cone penetrometer, which consists of a proving ring attached to one end of a metal shaft with a calibrated metal cone at the other end. By means of a push plate on the ring the cone is forced into the soil to a depth of 45 cm while the dial gage of the proving ring is read at 5-cm intervals. The gage and rings are calibrated to read out the force in pounds per square inch** required to penetrate the soil.

6. Although CI has not yet been directly linked to dust occurrence, its relation to bearing strength is well established and with proper understanding should lead to a linkage. An important reason for seeking such a relation is the fact that cone index is easily obtained in the field in sufficient quantity to permit mapping of the sites. Cone index can also indicate subsurface structure.

7. Moisture content (MC). When time and conditions permit, a moisture survey of the site should be made by taking moisture measurements (U. S. Army Engineer Waterways Experiment Station 1962) at regularly spaced intervals, as with the CI data. This is more time-consuming and should be done only if the probability of rain occurring before the tests is very small. Measurements should be made at the surface in each soil type where stratification occurs, and otherwise with occasional measurements at 30- to 45-cm depth.

8. If MC is measured by means of a core sample, the same material may be used later for bulk testing. The core sample is obtained by pressing a metal sleeve of known weight and enclosed volume into undisturbed soil and carefully extracting it with the sample intact. After shaving off excess soil material at the ends of the sleeve, the soil may be pressed out into a sealable container for later weighing or may be

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* References cited in this Appendix are more fully identified in the References section at the end of the main text.

** A table for converting inch-pound to metric (SI) units of measurement is found on page 3 of this report.

weighed at once in the sleeve. It is important that moisture not be lost before this weighing occurs. The material must then be dried in an oven and weighed a second time. In this way both the wet density and dry density of the sample are obtained from which MC is computed. The used material may then be combined with others to provide a larger bulk sample for laboratory analysis. Moisture content can also be determined by using the Speedy Moisture Tester (Alpha Lux Company 1970).

Vegetation

9. Properties of vegetation that may be considered to influence the dust-producing properties of the soil are vegetation type, structure (U. S. Army Engineer Waterways Experiment Station 1968), and vigor. The characteristic of a plant probably bearing the most influence is its rooting structure, which varies with species, soil type, and climatic conditions. The primary form of a root is governed by growth characters of the species, but environment also plays a part in determining the form a root system takes. Such factors as water content, aeration, soil structure, and nutrients can bring about root modifications. Sometimes variation is so great that roots are scarcely recognizable as belonging to the same species. The roots function to bind the soil loosely or tightly, affecting dust production. Plants in vigorous condition also tend to bind the soil more tightly than do dead or wilted plants.

10. Some plants have a dominant, deep taproot, while other plants form a fibrous network of small roots. The fibrous, shallow network is likely to bind the soil more closely than does a single deep taproot.

11. The distribution of a certain type of plant over a given area can influence dust production. If a fibrous rooted plant such as a grass covers the area of interest, dust production would be less. Conversely, if plants were sparsely distributed over the same area, dust production might be nearly equal to that of a completely denuded area.

12. To sample the vegetation present, a quadrat should be laid off (Weaver and Clements 1938). A quadrat is a square area of measured size marked off for the purpose of detailed study. By the study of numerous quadrats a knowledge of vegetation structure may be obtained.

The size of the quadrat is dependent upon the vegetation to be characterized. The 1-m quadrat is used in grassland and other herbaceous vegetation, while in areas where plants are large and widely spaced, a quadrat of 100 m may be employed.

13. To quantify the effect of vegetation on dust production, quadrats are laid out in representative locations in the area of interest. Each species present is listed, described, and counted, and its approximate areal coverage noted. The approximate area of foliage species is estimated, i.e., square centimetres of leaf area per stem or plant. Root structure is noted, and root counts may be taken. In the latter case the object will be to obtain a root density in terms of root stems per unit area of soil surface.

14. The biomass of the aboveground vegetation in the 1-m quadrat is determined by clipping the plants at ground level and putting the clippings in a plastic bag for later determination of wet and dry weights in the laboratory. A trench 1 m long along the boundary of the quadrat is then dug. This excavation shows the configuration of roots below ground level. A depth of 0.5 m is usually sufficient to include the roots of most herbaceous plants. A sketch should be made to illustrate the nature of the root structure, and a photograph showing a scale indicator such as a metre stick should be made of the exposed roots. To obtain a more quantitative measure of root biomass, the organic content with depth should be determined. A core sample should be taken to the depth of the deepest root. Ten-centimetre sections of this core should be separately bagged for laboratory determination of organic content by depth.

In Test Observations

15. The object here is to sample the soil at the point of testing under the conditions that exist at the time of the test. If the test occurs at a previously sampled grid point and no rain or other change has occurred, only those data not already obtained need be taken. Otherwise, density, MC, and CI measurements could be repeated--MC at the

surface and at the 30- to 45-cm depth, and CI at three points separated by at least 0.5 m around the test site. A bulk sample should be obtained for analysis of organic content, size gradation, and Atterberg limits.

16. After the dust event it is necessary to assess the nature and extent of the disturbance of the soil. If explosive events are involved, this will include crater measurements. For vehicle tests the area of disturbed soil as well as depth should be measured or estimated. The object is to determine the mass or volume of soil that has been displaced.

17. Location of the disturbed area is recorded mainly for purposes of correlation with the photographic documentation. This may be done with a surveyor's chain or steel tape if suitable reference marks exist. If references are too far away, a transit and rod may be necessary.

18. The crater diameter is measured in two directions at right angles. In the case of artillery burst, these are along and transverse to the firing axis. The diameter is measured at the intersection of the crater wall or its extension and the original surface line. Depth is measured from the original surface level to the visible or apparent crater floor (top of fallback material). For small craters this is easily done by laying a rod or straight beam across the crater and scooping away rim material to allow the ends to rest at the original surface line. For larger craters a transit and rod may be necessary to measure the depth; in this case, care should be taken to assure that the rod does not compress the material at the bottom.

19. For large or irregular craters, profile data give the best results. Profiles are measured by means of either the horizontal beam or the transit and extend beyond the lip material. They are taken at right angles, with the point of intersection noted on each, and measurement is to the visible crater surface. Spacing of the individual readings must be carefully maintained to allow accurate reconstruction.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Mason, James B.
Site characterization for Smoke Week III battlefield obscuration tests at Eglin Air Force Base, Florida / by James B. Mason, Katherine S. Long (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1983.
40 p. in various pagings : ill. ; 27 cm. -- (Miscellaneous paper ; EL-83-2)
Cover title.
"March 1983."
Final report.
"Prepared for Office, Chief of Engineers, U.S. Army."
Bibliography: p. 16.

1. Camouflage (Military science). 2. Dust control. 3. Smoke screens. 4. Terrain study (Military science). I. Long, Katherine S. II. United States. Army. Corps

Mason, James B.
Site characterization for Smoke Week III : ... 1983.
(Card 2)

of Engineers. Office of the Chief of Engineers. III. U.S. Army Engineer Waterways Experiment Station (Environmental Laboratory. IV. Title IV. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; EL-83-2.
TA7.W34m no.EL-83-2